

A Novel Enhanced Oil Recovery Method for the Oilfields of Upper Assam Basin and Analogous Reservoirs

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Abstract : *In this paper the authors have devised a novel technique of Enhanced Oil Recovery with the help of a case study of Barail Sandstone of Shalmari oilfield of Upper Assam Basin. The authors have done investigation of Reservoir Rock and Fluid Samples and different phenomena occurring in the Petroleum Reservoir with Thermo-Gravimetric Analysis, X-Ray Diffraction, Scanning Electron Microscope photograph, and Viscosity Analysis to find out the ideal conditions of Enhanced Oil Recovery in the reservoir. From these analyses, the authors have devised a combination of Thermal and Chemical recovery method which is ideal for the industry and which can give maximum ultimate recovery with minimum investment and without causing much damage to the reservoir. In addition to designing the perfect concentration and type of chemicals to be used and determining the best range of temperature in which the injected fluid to be send, the authors have proposed the idea of using solar energy to heat up the water before injecting it underground and hence paving the way for Solar EOR in Upper Assam Basin to decrease the viscosity of the crude oil. The Enclosed Trough Technology illustrated here for oil recovery is an extremely promising one and is a sustainable method of generating hot water/ steam keeping in view the degradation of the environment. This technology can be further extended to analogous reservoirs all over the world having reservoir characteristics similar to Barail sandstone of Shalmari oilfield.*

Key words: Solar EOR, Enclosed Trough System, Upper Assam Basin, Industrial Feasibility, Sustainability.

INTRODUCTION:

At present hydrocarbon productions have been experiencing downfall in many basins of the world due to oilfield maturity and an example of this includes the major oilfields like Shalmari in the Upper Assam Basin. [7] Another significant concern is the rapidly increasing energy demand due to worldwide population growth and mounting problems in discovering new oilfields. Therefore, there is a need to utilize alternative technologies to improve oil recovery from existing oilfields around the world. It is an undeniable fact that fossil fuels will still continue to be the primary supply of energy source for many years to come in spite of the huge investments in other sources of energy such as biofuels, wind energy, etc. This fact is further highlighted by the current global energy production from fossil fuels which stands at about 80-90% with oil and gas representing about 60-70 %. [6]

Many of the oilfields in the Upper Assam Basin are in matured stage by now and are now excellent candidates for Enhanced Oil

Recovery. Although much researches have been done in EOR related to Upper Assam Basin, but the oil companies have not yet been able to implement many of them due to the lack of the ideal conditions.

Shalmari is a major oil producing field situated in North-Eastern India and was discovered in 1986. Oil and gas are generally found in the Barail formation of the Oligocene play. [10] Till date, 30 wells have been drilled in this region with current production rate of around 690 m³ /day from Oligocene sandstone reservoirs. [8] The high viscous and waxy crude of Shalmari Oilfield is not only difficult to produce but also difficult to transport it through pipelines. [9] So, focus has been given to devise a novel thermo-chemical method utilizing innovative thinking and latest technology such that there is maximum recovery at minimum cost along with ensuring long life of the oilfield. This proposed EOR method should be more efficient in increasing the total recovery than the conventional thermal and conventional chemical method also.

This thought has led to the idea of using solar energy, which is a renewable source of energy to produce the waxy and viscous oils from Barail formation of Shalmari Oilfield.

Solar energy concentrating systems can serve various applications beyond electric power generation. Different industrial processes need thermal energy at temperatures and conditions amenable to solar, if the cost of solar steam or hot water is comparable with existing fuels without subsidies. One such radical application of particular interest is solar thermal enhanced oil recovery (EOR), which replaces fuel with sun's heat as the energy source of hot water or steam for oilfield operations. In thermal EOR, hot fluid is injected into the oil reservoir to heat up the formation. This improves production rates, primarily by raising the temperature of the oil-bearing formation and decreasing oil viscosity. Heating liquid-saturated rock by around 100°C requires large amounts of primary energy. Solar generators can deliver up to 80% of the oilfield hot fluid requirement. Current EOR operations worldwide consume more than 1.7 billion MMBTU of natural gas annually, with substantial growth predictions. Use of solar energy to generate heated fluids for EOR presents unique challenges for concentrating solar energy. Initial and operating costs must compete with natural gas. Boiler feedwater is either the "produced water" which is separated from produced oil or is pumped from aquifers. Since, it will be directly injected into the reservoir; water treatment costs must be minimized to achieve acceptable economics. [5]

Experiment and Observations:

1. Thermal EOR- Change of Viscosity with temperature:

The effect of temperature on Viscosity was studied on crude sample collected from well SLM# XX to illustrate the temperature conditions for thermal EOR.

Table-01: Variation of Plastic Viscosity of Crude Oil with temperature

Temperature (Degree Fahrenheit)	Plastic Viscosity, CP
80	3.6
90	3
100	2.7
110	2.5
120	2.3
130	2.1
140	1.9
150	1.7
160	1.5
170	1.3
180	1.1
190	1
200	0.9
210	0.8
220	0.8

A fairly valuable result was obtained in view of the optimum temperature range to be maintained for the hot water or steam to be injected for the EOR process. From the graph (Fig. 01), it can be observed that when the temperature is below 37.77 °C (100°F), the viscosity of crude oil (collected from Barail sands of Shalmari Oilfield) decreases rapidly with increase in temperature. Again in the range of 37.77 °C and 98.88°C (210°F) the decreasing rate of viscosity is quite gradual, but it continues to decrease. On the other hand as temperature increases above 98.88°C, the rate of Viscosity decline is almost constant. So, it is clear that increasing the temperature of reservoir above 98.88°C has a rather slow effect on the Oil viscosity as compared to increasing the temperature below 98.88°C. Therefore, it would be beneficial in the sense of recovery efficiency, if it can be able to maintain the reservoir temperature in the range of around 95-100°C.

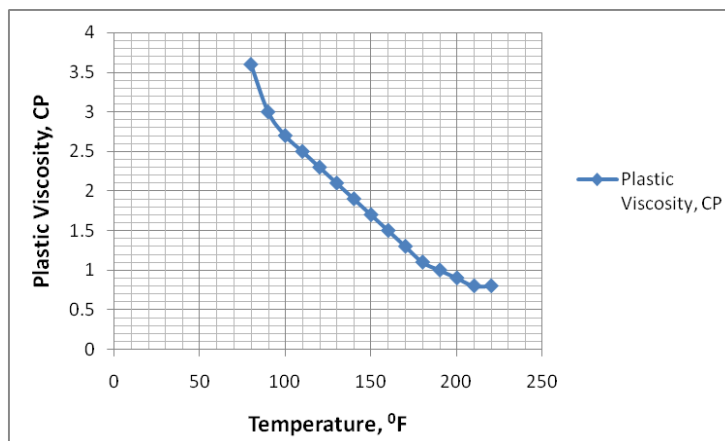


Figure 01: Graph illustrating the change in crude oil viscosity with temperature

2. Thermo-Gravimetric Analysis (TGA):

Next, TGA was conducted on the crude samples to know the temperature range to be maintained at the reservoir so that the crude oil viscosity does reduce with temperature but does not go down beyond a certain level such that there is rapid degradation of the mass of the crude. Because, if there is rapid degradation of the mass of the crude, then it may reach to a totally gaseous state and in the long run complicate the entire process by a gas breakthrough. This test will give us the upper range of temperature which should be maintained during the thermal EOR Process. As can be observed from the TGA Analysis in the Figure 02, it can be concluded that if the reservoir temperature can be maintained below 134.837°C then the rapid degradation of mass of the crude oil present in the reservoir can be eliminated.

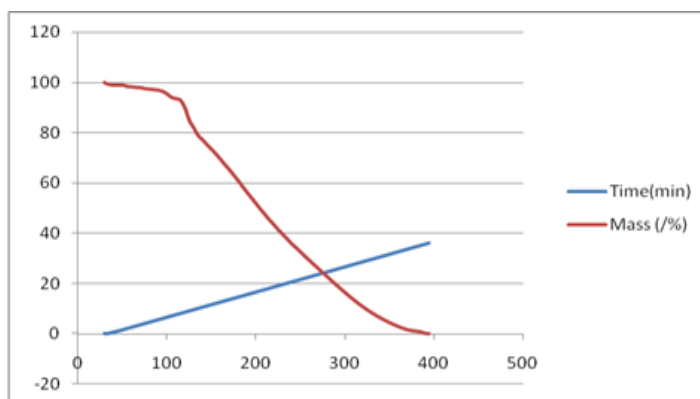


Fig. 02: TGA plot of Crude sample collected from Shalmari Oil Field

3. Chemical EOR:

As evident in earlier research work, from XRD and SEM analysis the presence of swelling clay Smectite, and clays with emigrational fines problem like Kaolinite and Illite etc. in the Barail (and Tipam) formations of most of the reservoirs of Upper Assam Basin which may damage the reservoir during hot

water or steam flooding.[2][3]Finally after investigation it was found that 5% KCl solution can be used to prevent clay swelling and in turn minimize damage to the reservoir.[1]

From previous literature, the IFT (Interfacial Tension) can be decreased below the necessary level using Black Liquor, the main constituent of which is Na-lignosulfonate along with Co-surfactant. Black Liquor, an effluent produced from the Nagaon Paper Mill, Jagiroad, Assam, can be easily used in the oilfields. The main advantage of lignosulfonate over other market-available sulfonate is that they are around four times cheaper and are available in huge quantities as by-product from the paper industries. This approach is also competent for sustainable development of environment. [4]

4. Proposal of Enclosed Trough Technology for Solar EOR in Upper Assam Basin:

At present the Steam/Heat Generators use fossil fuels for Thermal Enhanced Oil Recovery Operations (e.g. Hot Water circulation, Steam Drive and Huff & Puff Method). Following are the inherent problems in their use:

- 1) Their burning causes pollution of different nature and degrading the environment.
- 2) They are non renewable and exhaustible in nature.
- 3) These fuels are quite costly.

In order to combat these problems it can be proposed the use of Solar Energy to generate the necessary heat required for the thermal EOR process since solar energy is clean and requires only installation and maintainance cost (since the source of energy (Sun's heat) is abundant and free).

In the proposed technology, the enclosed trough structure basically encapsulates the solar thermal system within a greenhouse-like glasshouse inside which the heat from the sun can only enter but cannot escape. The glasshouse also creates a safe environment to withstand the elements that can adversely impact reliability and efficiency of the mentioned solar thermal system. Lightweight curved solar-reflecting mirrors also called parabolic mirrors, are suspended within the glasshouse structure. A single-axis tracking system positions the mirrors to track the sun and then focus its light onto a network of static steel pipes, also suspended from the glasshouse structure. Steam is then generated directly using, oil field-quality water, as water flows from the inlet throughout the length of the pipes, without heat exchangers or intermediate working fluids.

The steam produced is then fed directly to the field's existing steam distribution network, where the steam is continuously injected deep into the oil reservoir. Sheltering the mirrors from the wind allows them to achieve higher temperature rates and prevents dust from building up as a result from exposure to humidity. For this the enclosed trough system can be fitted with an automated roof washing system, which may be capable of cleaning up the roof surface every night while the solar collectors are offline.

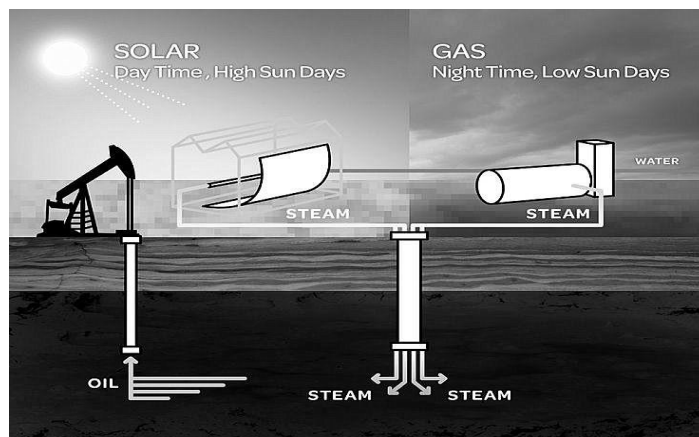


Figure 03: Solar EOR using parabolic reflectors (Courtesy: PetroWiki)

In terms of climate, the Shalmari Oilfield falls in a mostly sunny region and hence, if applied, it can be a bright scope for EOR in the near future. In order to maintain the hot fluid/ steam injection around the clock, solar steam maybe injected during the day (when there is abundant sunshine) and steam produced by diesel or natural gas may be injected at night or cloudy weather.

CONCLUSION:

From the different investigation, it was found that the ideal temperature range for conducting Thermal EOR in Barail formation of Shalmari oilfield in Upper Assam Basin is 98.88°C - 134.837°C. The necessary heat energy for this process can be easily generated using Enclosed Trough system of Solar EOR which will be both cost effective and environment friendly. Along with the slug of Hot Water/ Steam, the Black Liquor (Surfactant) may be injected periodically whose prime component is Na- lignosulfonate (to reduce the IFT value below 17.2 mN/m) and also a solution of 5% KCl (to prevent the swelling characteristics of Smectite clay present in the formation) may be added to the injected solution. Thus, based on the case study conducted in a portion of Upper Assam Basin, it can be concluded that the described method will obviously be a novel Enhanced Oil Recovery method. This method will not only help in improving recovery from different parts of Upper Assam Basin but also from analogous reservoirs around the world having same reservoir rock and fluid properties similar to Barail formation of Shalmari oilfield.

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